Process Evaluation Section

Recycling of Polymer Matrix Composites (PMCs)

Problem/Opportunity

Carbon fiber reinforced polymer matrix composite (PMC) materials are exhibiting such high strength-to-weight ratios that they are finding increasing applications in the aerospace industry. They are also being evaluated as possible construction materials in the automotive industry. The major barriers to their widespread use is their high cost and concerns about whether they are going to be recyclable when the vehicles reach the end of their useful lives. With funding provided by the Office of Advanced Transportation Technologies, Argonne is developing an efficient and cost-effective process to recover the high-valued carbon fibers.

Approach

Two processes to separate carbon fibers from PMC samples containing urethane and epoxy substrates have been tested that were successful in liberating the carbon fibers: thermal treatment and chemical treatment.

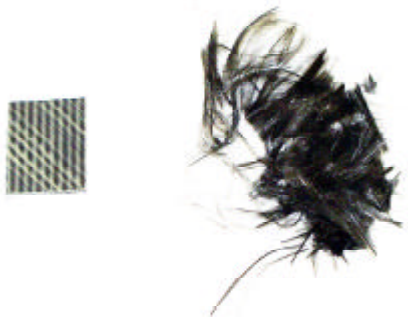

Figure 1. Untreated PMC Samples (Left) and Recovered Carbon Fibers after Thermal Treatment (Right)

Bench-scale experiments conducted on the chemical degradation method demonstrated that separation of the carbon fibers from their polymer matrices could be achieved in a three-step process. However, fibers separated by means of this method contained a layer of coating that was not identified. The fibers were also more brittle than those produced by the thermal treatment method.

The thermal treatment method, which is a single-step process, produced higher-quality fibers with properties resembling those of their virgin counterparts and produced no liquid waste.

Fibers recovered by means of this method were found to have density and electrical properties that are essentially the same as those of the virgin polyacrylonitrile (PAN) fibers. The mechanical properties of the resulting product were evaluated and are adequate for “short fiber” applications. The thermal treatment process was selected for continued development.

A continuous thermal reactor capable of treating 5 kilograms per hour (kg / h) of PMC material. The reactor can be heated using infrared radiation and / or electrical resistance heaters. It can achieve a muffle temperature of 1,900°F. Preliminary experiments were successfully conducted in the continuous reactor. PMC samples having any desired length and as wide as 5 inches and a thickness of up to 0.5 inches can be treated in the reactor in either air or in nitrogen. The economics of the process were also re-evaluated in view of more experimental and design data and the

results showed a potential payback of one year.

Results

Based on the experimental data generated in the laboratory, the thermal treatment method has been selected for further development for recycling PMC materials. The process produces fibers that are suitable for short-fiber applications and it has a potential payback of one year.

Future Plans

We plan to conduct process improvement studies using the continuous reactor to determine the optimum operating conditions that will result in minimum cost and maximum energy savings. Disposal requirements and treatment, if required, of the effluent stream will be defined.

Figure 2. Continuous Thermal Treatment Reactor